# Integrated Receiver and Switch Technology (IRaST)

Completed Technology Project (2017 - 2019)

## Project Introduction

Northrop Grumman Corporation (NGC) with the Jet Propulsion Laboratory (JPL) propose development in two technical areas for this ACT - Integrated Receiver and Switch Technology (IRaST): 1) A highly integrated heterodyne receiver capable of simultaneously observing the 424 GHz oxygen band and the 448 GHz water vapor band 2) Submillimeter wave switch technology using InP HEMT to allow 1/f noise reduction in front-end Low Noise Amplifiers (LNAs) integrated onto the same integrated circuit (IC) Both developments will be done on NGC InP 25nm HEMT technology by designing and processing a dedicated foundry run for this project. NGC and JPL will work closely on the design of the components, packaging and testing, and analysis of the radiometric characteristics. IRaST is expected to have significant benefits for atmospheric science. The integrated receiver for temperature and water vapor profiling of the upper atmosphere will provide detailed information of the atmosphere between 6 to 16 km in tropical atmosphere and will increase nadir resolution and will reduce aperture size when used for limb sounding. The integrated switch technology will improve cloud ice measurements by reducing the 1/f noise contribution in low DC power direct detection receivers being developed on TWICE and intended for application to ENTICE. Application of 25 nm InP HEMT technology to both of these problems will provide a scientific solution with considerable benefits over existing technologies in terms of Size, Weight, and Power (SWaP) enabled both by the high level of integration which is bought by MMIC technology and DC power savings. We estimate the upper atmosphere temperature and water vapor profiling receiver to consume approximately 1 W of DC power excluding the X-Band LO. 660 GHz direct detection receivers consume approximately 120 mW, compared to 6-10 W of DC power consumed by a heterodyne receiver in GaAs Schottky technology. Therefore, both of these technologies are ideal CubeSat applications. The upper atmospheric temperature and humidity sounding receiver will be developed by JPL using proven models for 25 nm InP HEMT provided by NGC. Two full design iterations will be completed by JPL, along with corresponding design, layout, component measurements, and receiver validation. Development will start from LNA's developed on IRAD. The LNA will be integrated with an I-Q mixer which will allow separation of both the 424 GHz oxygen line and the 448 GHz water vapor line. The integrated Dicke switches will be developed by NGC using IRAD designs which have already been analyzed and layouts created. NGCs second design iteration will be aided by device modeling. The Dicke switches will be combined with existing direct detection receivers and radiometric performance will be evaluated. Impact to receiver sensitivity will be managed by placing an additional balanced LNA in front of the Dicke switch. This technique has been proven at W-Band and reduces the 1/f noise contribution of the additional LNA. Two MMIC design iterations are budgeted in NGC's 25 nm InP HEMT process. The Period of Performance (PoP) for IRaST is 24 months. This allows time for the two full design iterations, wafer processing, and receiver validation. With the underlying semiconductor technology already in existence, and models


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## Organizational Responsibility

**Responsible Mission Directorate:**

Science Mission Directorate (SMD)

**Lead Organization:**

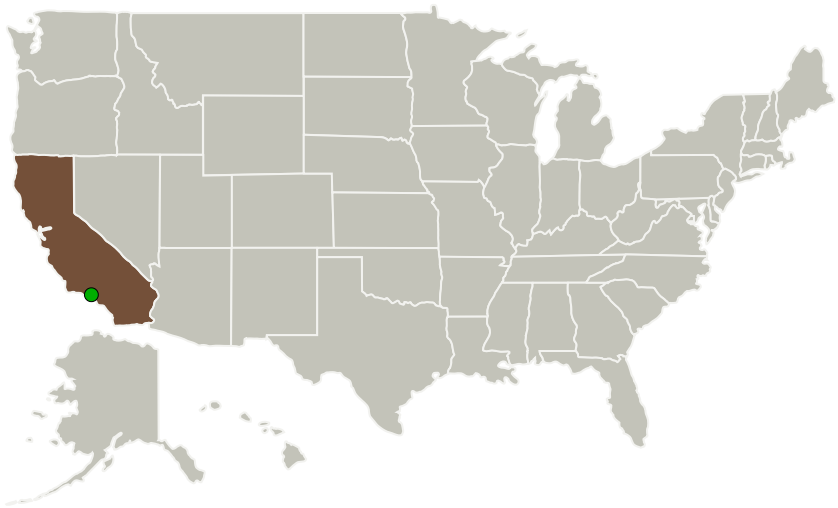
Northrop Grumman Systems Corporation

**Responsible Program:**

Advanced Component Technology Program

showing the feasibility of the proposed IRaST tasks, entry TRL level is TRL2. IRaST will complete with packaged receiver measurements in a laboratory environment. Therefore, exit TRL is TRL4. This represents a two level TRL increase over a two year period. Both JPL and NGC have had considerable success at developing new technologies and inserting them into NASA or DoD missions.

### Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Northrop Grumman Systems Corporation | Lead Organization | Industry | Falls Church, Virginia |
| Aerospace Systems | Supporting Organization | Industry | Redondo Beach, California |
| Jet Propulsion Laboratory(JPL) | Supporting Organization | NASA Center | Pasadena, California |
| Northrop Grumman Aerospace Systems(NGAS) | Supporting Organization | Industry | Redondo Beach, California |

## Project Management

**Program Director:**

Pamela S Millar

**Program Manager:**

Amber E Emory

**Principal Investigator:**

William R Deal

**Co-Investigators:**

Boon H Lim
William R Deal
Pekka Kangaslahti
Kevin Leong

## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

## Target Destination

Earth

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California